

Energy Choices for the 21st Century

It is suggested that human activities since the Industrial Revolution have magnified the normal warming trend of the earth's climate. The natural greenhouse effect is largely responsible for the habitable conditions on earth and it is caused by the presence of an atmosphere containing greenhouse gases which trap heat given off by the Earth. Without a natural greenhouse effect, the average temperature of the Earth would be 0 degrees Fahrenheit instead of its present 57 degrees Fahrenheit.

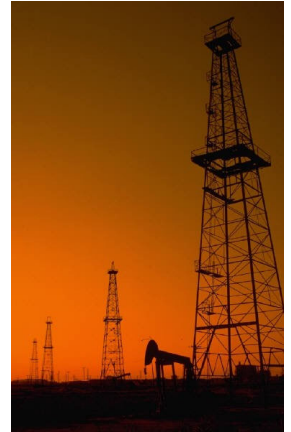
Since the industrial revolution, humans have become a factor in climate by consuming large quantities of fossil fuels such as petroleum, coal and natural gas. Burning fossil fuels release additional greenhouse gases, such as nitrous oxide, methane and carbon dioxide into the atmosphere. These gases trap more heat that would otherwise leave the planet, therefore causing the average global temperature to increase. This rise in the earth's average temperature further induces evaporation and therefore increases the presence of water vapor, another greenhouse gas, in the atmosphere. Many scientists believe that all these factors lead to what is known as the "global warming".

We are doing climate simulations for the period 2000-2050 for an IPCC "business-as-usual" scenario and for a specific "alternative" scenario.

There are three key elements in the A-scenario:

- the CO₂ growth rate levels out and begins to decline slightly during the 50 year period,
- the CH₄ growth rate, which has been declining in the past 20 years, declines further and becomes negative, such that CH₄ in 2050 is actually less than it is today and
- black carbon aerosols, which cause warming, will decrease, or at least their growth rate will slow down enough that the net aerosol forcing will not increase (sulfates, which cause cooling, may decrease in amount, at least in many regions).

The goal of this project is to break down energy numbers into component parts that relate to what people are doing, and to develop alternative energy scenarios that seek zero growth rate in CO₂ emissions.



Carbon Sequestration in New York's Black Rock Forest

Humans alter Earth's land-surface through various activities, impacting the vegetation, soils, and wetlands where carbon is stored. These carbon reservoirs have an influence on changing atmospheric composition and can even contribute to climate warming or cooling.

Exciting results in the last five years have placed a fundamental science question concerning carbon storage squarely in the lap of terrestrial ecologists.

How much carbon is being stored on the terrestrial part of the earth? How much is in the trees versus in the soils? How does this carbon sequestering vary over time?

We have a chance to make a real contribution to this question by using our combined carbon and pollen/climate research in the



Hudson Watershed. Black Rock Forest is a representative oak forest where research scientist Bill Schuster, is now studying carbon storage in the trees. We can study this forest carbon as well, with land-use variations (fire) as we began to do last year. In addition, we can measure the carbon in the soils, and use Black Rock Forest wetlands such as Sutherland Bog and Glycerin Hollow, where we have some ongoing pollen/climate research. Then we can add to the carbon soil sequestration measurements by studying Hudson River marsh sites such as Croton Marsh and Jamaica Bay wetlands.

The advantage of using both wetland pollen/climate and carbon studies in connection with the forest landscape carbon study is that when the pollen shows changes in trees over time due to climate change, the carbon storage in the wetland will provide a measure of the influence that vegetation change makes.

Thus we will be able to make estimates of present carbon storage in forests (dry soils, wetland soils) with present vegetation, and past and future carbon estimates in soils when a different vegetation (and climate) would be present. It is an ideal combination – and together we can begin to answer questions about the northeastern US "missing sink", which is about one-third of current US emissions.



Aerosols and Health: Environmental Linkages to Asthma

How do concentrations and spatial distribution of atmospheric particulates (aerosols) or pollutants (aerosol precursors) affect the climate and asthma burden? Millions of people of all ages around the world suffer from asthma. Asthma is a complex disease, influenced by multiple factors or triggers. One asthma trigger is pollution, in particular, concentration of atmospheric particles in our atmosphere called aerosols. NASA's unique contribution to the study of human health and the environment is the observation, measurement, analysis and modeling of Earth's atmospheric and surface properties on regional to global scales.



This project helps to quantify the potential relationship between the alarming increase in the prevalence of asthma and global and decadal scale changes in atmospheric composition and climate due to human activity. One dimension of the research focuses on the relationships that can be found between asthma, environmental and socioeconomic factors analysis of data from an Asthma Survey administered to students attending high schools in four cities: New York, NY; Camden, NJ; Washington, DC; and Fillmore, CA.

A second study area attempts to determine the spatial distribution of aerosols in New York City and the main aerosol sources using a combination of NASA and EPA data supplemented with their own measurements. The instrumentation used to collect aerosol measurements are Multi-Filter Rotating Shadowband Radiometers (MFRSR) located at GISS, City College of New York, Medgar Evers College, Lamont Earth Observatory, as well as hand held sunphotometers and

Microtops II. Measurements from the MFRSR and hand held instruments are processed to obtain atmospheric optical depth in six spectral channels (wavelengths). These total optical depths can then be analyzed to obtain aerosol optical depth providing an indication as to the concentration of aerosols in the atmosphere, i.e. column loading of the aerosols.

The measurements from all of the sunphotometers will be combined to investigate the spatial variability of aerosol with EPA measurements used to constrain the concentrations of aerosol precursors. Collectively, the team will use their results to evaluate how the scientific instruments and asthma survey data, as well as their research findings might help produce more informed policy decisions if it were applied on a broader scale.

Global Methane: Assessing Historical Trends and Future Scenarios

Atmospheric concentrations of greenhouse gases have increased substantially in the last two centuries. Increases in these gases, including methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) are most likely due, in part, to anthropogenic (human) activities.

The overall scientific objectives of our research are to understand the global methane cycle, including how its sources and sinks have changed over the last 20 years, how they might change in future decades, and what the implications are for climate.

The objective of this project is to estimate global methane emissions for all sources, all countries and every year from 1980 onward. These estimates rely on internationally recognized methods for estimating sources, as well as on new approaches to estimating emissions. These data contribute to interpreting, understanding, and predicting changes in atmospheric constituents and their impact on climate.

This research project is an interdisciplinary study of global and regional methane sources where students study historical changes in methane emissions in order to understand their potential role in climate change. This is done by first investigating the potential contribution of a suite of anthropogenic and natural methane sources to interannual variations and decadal trends in atmospheric methane concentrations.

We are investigating the following sources: animals, irrigated rice cultivation, landfills, and production and consumption of fossil fuels (natural gas, oil, and coal) (anthropogenic), and wetlands (natural) for the period 1980 to the present.



Modeling the World's Oceans for Climate Prediction

In order to advance our understanding of the Earth's climate system and predict future climate change, atmospheric and ocean processes are mathematically simulated in computer modeling programs called General Circulation Models (GCMs).

There is a great deal of uncertainty in using this scientific tool to predict future climate. Scientists at GISS are actively involved in studies to test the capability of the GISS GCM and using the results of their analysis to make improvements.

Simulating the ocean and atmosphere requires understanding dynamic fluid processes influenced by the complex characteristics of nature and human activities. The difference in climate between fully coupled ocean-atmosphere models and models run with fixed sea surface forcing demonstrate the importance of ocean processes in determining climate.

The new GISS GCM has been coupled to various ocean GCMs. These "coupled" models will be used to predict ocean uptake of heat captured by anthropogenic greenhouse gases, along with the resulting regional patterns of the ocean response.

As a prerequisite to these calculations, the project team will evaluate the coupled model's ability to simulate general features of the ocean circulation, such as the Gulf Stream, thermohaline circulation, El Nino, and water mass trajectories.

Specifically, the project team will examine the output from climate simulations using fully coupled ocean-atmosphere models and models run with fixed sea surface forcings to:

- determine how accurate the simulated ocean processes are, and
- determine whether the atmospheric variability with an fully coupled ocean is more or less realistic than the fixed forcing run.

In particular, the team will examine the processes of water mass formation in the simulated ocean since these are very effective diagnostics of the reality of the ocean simulation. A more general aim will be to examine how climate variability is connected across the globe.



Storms and Climate Warming: Changes in Intensity, Cloudiness, Rainfall and Damages

This project deals with the question of how weather conditions will be different in a possible future warmer climate. In the middle latitudes, where most of the world's population lives, the major weather-makers are midlatitude storms that mix cold and warm air masses and produce high winds and precipitation.



To explore how different the midlatitude weather of a warmer world will be from the weather we experience today, it is important to understand how the properties of midlatitude storms may change as climate warms.

What will midlatitude storms in the future look like in terms of their intensity, frequency, severity, tracks and cloud properties? How well does the GISS General Circulation Model reproduce these storm characteristics and what is the assessment of its capability to predict future storms? Can we apply research findings to study the potential economic risks of the storms that we may expect in a future warmer climate?

Midlatitude storms are disturbances that form along the jet stream (the river of air that circumnavigates the globe in the Northern and Southern midlatitudes) and travel with it in an eastward direction. The jet stream draws its energy

from the large temperature differences between the earth's equator and poles. In a warmer climate, the temperature difference between those two regions will be smaller and this may result in a slower, less energetic jet stream. Does this mean that a warmer world will experience fewer or weaker midlatitude storms?

In our attempt to profile the storm of the future and its effect on the economy, our group will build on the knowledge that can be gained from studying the storms of the past and on predictions made using the GISS climate model. We have developed tools that scan weather data to locate and track midlatitude storms as well as tools that collocate and correlate storm and cloud properties from weather and satellite observations, and we have developed a thirty-year climatology of storms.

We also have datasets that describe economic damages from storms over the same thirty-year period. Combining the different parts of our analysis, we will attempt to resolve how the frequency and strength of midlatitude storms will change in a warmer climate and what such changes will mean in terms of the weather conditions and their economic effects in the midlatitude regions.

Climate Impacts in New York City: Sea Level Rise and Coastal Floods

Large cities are at the forefront of both vulnerability and adaptation to climate impacts. These cities are commonly located on the coastlines and are home to a rapidly growing percentage of the earth's population.



The need for understanding potential climate impacts in urban areas is growing, as urban dwellers and decision-makers are being challenged to devise new types of adaptations and adjustments.

This project addresses two important research topics of the recently conducted Metropolitan East Coast Regional Assessment of the Potential Consequences of Climate Variability and Change – Sea-level Rise and Coasts and Water Supply.

The project team will study regional trends and identify scenarios for future trends. One important challenge to the team will be to evaluate the potential impacts these trends and scenarios might have on human and natural systems, as well as to produce a metro area risk assessment.

They will also work with the Clouds team in a comparative study to evaluate economic storm damage for Midwestern and Northeastern states, 1950 to the

Present. Some of the guiding science questions are:

- a. What is the likelihood of droughts and floods in the Metro East Region?
- b. What are the costs of these extreme weather events?
- c. How can citizens and policy-makers adapt and mitigate these potential climate impacts?

Green Roofs

The concept of integrating Green Roofs into urban architectural design is gaining worldwide acceptance to mitigate the negative impacts of the urban heat island effect, as well as storm water run-off, a major source of water pollution. Green Roofs can also help urban areas adapt to global climate change.

GISS researchers in collaboration with Earth Pledge and other research organizations in the New York Metropolitan Region are embarking on a NYC Green Roofs Research Project. This is the newest research project to involve ICP student and teacher researchers.

During the 2003/04 school year, NYC's School of the Future will produce a blueprint for building a school-based Green Roof and experimental results to quantify the impact of a Green Roof on run-off rates and the efficiency of different soils and plant types to produce cooling effects and improved water quality.

This initial study is designed to contribute to the New York Ecological Infrastructure Study (NYEIS), initiated by the Earth Pledge Green Roofs Initiative and led by researchers from the EI at Columbia University and the NASA GISS.

Science Question: What are the costs and benefits of Green Roof infrastructure in the New York metropolitan region, and how do the results of this study contribute to policy decisions?



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